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AGRICULTURAL MEMORANDUM NO. 635

EXCESS WINTER RAINFALL IN THE NORTH OF SCOTLAND

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Excess rainfall is a significant factor in the leaching of nutrients and of lime from the soil, and is of importance in land drainage. It has been calculated for each of the twenty years 1954 to 1973 for 44 stations in the main agricultural areas of Scotland, using the method of M.A.F.F. Technical Bulletin No. 24[1]. The material has been divided into three regions. Data for 17 stations in the North of Scotland are given in this paper. The East of Scotland is covered by 16 stations in Agricultural Memorandum No 636, and the West of Scotland by 11 stations in Agricultural Memorandum No. 637, the division being on the basis of the Areas of responsibility of the three Colleges of Agriculture in Scotland.

2. Meteorological records for the twenty-year period were analysed to give estimated soil moisture deficits at monthly intervals. These were the basic data used in the analysis. A few stations with shorter periods of record or non-standard periods were included to improve coverage. The calculation assumes that the first two inches (50 mm) of soil moisture are available for evaporation by the plant cover at the full potential rate, that the next two inches (50 mm) are available at half rate, and that a final one inch (25 mm) can be extracted at quarter rate, i.e. a limit to soil moisture deficit of 5 in. (125 mm). However, in any period with an excess of rainfall over evaporation requirement the soil will be moistened from the top, and the excess will be available for evaporation at the appropriate higher rate. Full details of this type of calculation are given in M.A.F.F. Technical Bulletin No. 16[2].

3. We define 'Excess Winter Rainfall' as the excess of rainfall over evaporation between the date of return of the soil to field capacity and the end of March. There is however a wide variation in date of return to field capacity from year to year and from place to place. At the one extreme a deficit of soil moisture remains throughout the entire winter, with zero excess winter rainfall. At the other extreme, in a high rainfall area there are likely to be several years in twenty when no soil moisture deficit develops. In the latter case the excess winter rainfall is assumed to commence in July. 'Excess Spring Rainfall' in the three months April to June is examined separately.

4. EXCESS WINTER RAINFALL

The mean values of excess winter rainfall (EWR) for the 17 stations are given in Table 1, in ascending order of annual rainfall (R) with which they are highly correlated. The relationship between EWR and R is given in millimetres by

$$EWR = 0.93R - 405 \qquad (1)$$

with a correlation coefficient between EWR and R of + 0.983. The annual rainfall averages for the period 1916-50 were selected for this comparison since these are widely available for the whole of Scotland. As would be expected the correlation with annual rainfall averages for 1954-73 was even higher, + 0.993. It must be stressed that these correlations are between the long-term averages of annual and excess winter rainfall, not for individual years.

The excess winter rainfall mean values are seen to range from about 25 per cent of annual rainfall in the southern coastal region of the Moray Firth around Kinloss and Nairn to about 50 per cent of annual rainfall in the high rainfall areas.

The standard deviation of the yearly values from the mean are given, also the upper and lower quartiles and the extremes. In about one year in twenty in the Kinloss/Nairn region a deficit of soil moisture remains throughout the entire winter, giving zero excess winter rainfall.

The standard deviation (s.d.) of excess winter rainfall is given by

$$\text{s.d.} = 0.17\ \text{EWR} + 55 \qquad \text{——————} (2)$$

with correlation 0.88. The two stations which fit this regression least well, Fyvie and Glenlivet, had only 14 years of record neither of which included the noteworthy dry years 1972 and 1973. But their exclusion would not significantly have affected the regression.

Estimates for any other station should be obtained from equations (1) and (2). These give values of excess winter rainfall and its standard deviation given only the 1916–50 annual average rainfall. Quartiles and approximate extreme values can be estimated by interpolation in Table 1.

5. EXCESS SPRING RAINFALL

Mean values of excess spring rainfall (ESR) are given in Table 2, together with maximum values for each station and frequency of occurrence of ESR. Excess spring rainfall at Kirkwall (Orkney) and Strathy (on the north coast of Sutherland) is much lower than for inland stations with similar annual rainfall totals. Excluding these two stations the regression between ESR and R is

$$\text{ESR} = 0.11R - 75 \qquad \text{with correlation } 0.94$$

Maximum April to July excess rainfall is given in Table 2 for each station, and the number of years in twenty in which excess spring rainfall occurred (N).

6. Comments or suggestions regarding this paper would be welcomed by the author.

References

1. "The Significance of Winter Rainfall over Farmland in England and Wales", Technical Bulletin 24, Ministry of Agriculture, Fisheries and Food, 1971.

2. "Potential Transpiration", Technical Bulletin 16, Ministry of Agriculture, Fisheries and Food, 1967.

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Table 1. Excess Winter Rainfall (EWR)

Station (a)	Height m	Period (b)	EWR Mean mm	s.d. mm (c)	Quartiles mm		Extremes mm		R mm (d)
Kinloss	5		160	85	115	175	0	350	615
Nairn	6		145	85	85	200	0	330	635
Fortrose	5		185	95	125	225	0	405	645
Inverness	4		175	95	80	245	10	375	660
Rattray Head	26	50–67	295	95	200	385	175	450	720
Banff	24		265	105	230	360	5	435	745
Fochabers	32		285	95	260	335	45	455	750
Wick	36		365	120	280	420	115	620	760
Stonehaven	4	41–60	315	100	240	400	145	530	770
Craibstone	91		385	130	320	460	45	630	860
Fyvie	66	58–71	425	95	345	490	280	640	880
Braemar	339		450	125	375	560	175	670	925
Glenlivet	331	47–60	475	115	400	575	325	700	925
Fettercairn	171		550	155	445	670	175	850	990
Kirkwall	26		540	135	400	660	300	780	1000
Strathy	38		545	155	415	640	295	860	1090
Dalwhinnie	358	39–58	745	185	590	825	535	1170	1250

(a) Stations listed in order of R.

(b) Period of differing from 1954–73.

(c) Standard deviation from mean value.

(d) Rainfall average 1916–50.

Table 2. Excess Spring Rainfall (ESR)

Station (a)	Height m	R mm (b)	ESR Mean mm	ESR Max mm	N (c)	Grid ref
Kinloss	5	615	2	19	2	NJ 0763
Nairn	6	635	2	12	2	NH 8757
Fortrose	5	645	4	32	4	NH 7556
Inverness	4	660	4	49	4	NH 6746
Rattray Head	26	720	2	9	(4)	NK 0958
Banff	24	745	0	0	0	NJ 6965
Fochabers	32	750	6	75	3	NJ 3560
Wick	36	760	3	30	6	ND 3652
Stonehaven	4	770	7	29	9	NO 8786
Craibstone	91	860	21	109	11	NJ 8711
Fyvie	66	880	31	112	(10)	NJ 7639
Braemar	339	925	24	79	16	NO 1591
Glenlivet	331	925	37	101	(16)	NJ 1930
Fettercairn	171	990	45	192	16	NO 6778
Kirkwall	26	1000	10	64	11	HY 4808
Strathy	38	1090	18	83	16	NC 8361
Dalwhinnie	358	1250	60	276	17	NN 6485

(a) Stations listed in order of R

(b) Rainfall average 1916–50

(c) Number of years in 20 with excess spring rainfall.
The numbers in brackets are from periods of record shorter than 20 years, scaled up to 20-year values.

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